in fact is international and universal. There is not an English entomology, nor a French paleontology, any more than there exists a Roman Catholic algebra or a Presbyterian geometry. We certainly have provocation, but the test of our scientific fitness is found in our ability to avoid the mistake of attempting to beat the Prussian by Prussianizing ourselves.

W. J. HOLLAND

CARNEGIE INSTITUTE,
October 18, 1918

THE FOUNDATIONS OF MECHANICS

MR. PAUL J. FOX, in his comments[1] on our article of August 2d seems to us to be mistaken in two particulars. Surely to *identify* a force, so that the same force can be reproduced at will and caused to act at one time on one body and at another time on another body, is not the same thing as to *measure* the force. If we are to compare the accelerations of different bodies due to a given force, some basis of identification of the force is necessary; for example, it may be the force which will produce a certain stretch of a given spring. To identify a force, or a temperature, is not the same thing, by any means, as to measure the force or temperature.

If Mr. Fox will read our article carefully he will see that we do not even imply that the quantitative idea of mass is necessary for either the identification of measurement of force. Every physicist knows, and knew long before Perrin's time, that a rigorous quantitative definition of force is possible in terms of stretched springs without assuming Hooke's law. But no one, perhaps, has ever measured a force in this way, and by *measuring* we do not refer to any kind of thinking nor to any mathematical operation, much as we love both of these categories; we mean a laboratory operation (troublesome though such things be), and especially we mean a laboratory operation which gives an invariant result irrespective of special properties of particular substances and independently of time and place.

Perhaps our deeper source of confusion may be, as Mr. Fox says, "in not making a distinction between mechanics as a 'doctrinal function' and as an experimental science." But we do not believe it; and for Mr. Fox to borrow the term in mild ostentation from Bertrand Russell leaves us unimpressed. Surely it is no mark of fixity of ideas on our part not to take Bertrand Russell over-seriously even in doctrinal mechanics and to always attend carefully to what has been said by Newton and Thomson and Tait, and Larmor.

Our mathematicians are rightly interested in the invariance of all kinds of functions with respect to a wide variety of transformations, and the physicist has seen many remarkable applications of this sort of invariance, the most remarkable of all being the recent generalized form of the principle of relativity; but the mathematician does not seem to understand that there is a kind of mathematics involved in the always more or less idealized operations and transformations of the laboratory with their amazing groups of invariances. Indeed, when we read such passages as the following from Mr. Fox's communication, fear that our mathematicians may never be able to fathom the deeper phases even of doctrinal physics—for the whole of the logical structure of the physical science is, let us borrow the phrase from Bertrand Russell, doctrinal.

"Thus it is clear that the units we have in the Bureau of Standards need not be the same as the undefined elements in the doctrinal function. We do not need even to imagine that Bureau keeping standard springs, rubber bands, strong armed men, etc., any more than it would keep a standard point (!) instead of a standard meter, for Veblen's system of geometry. Any equation may be made use of to measure any quantity which it contains." Mr. Fox, further on, quotes Frederic Soddy's statement that "the conception of force and its psendo physical reality undoubtedly delayed for centuries the recognition of the law of the conservation of energy, etc.," and states that there seems to a certain mysticism in Soddy's contention. Not at all. Let Mr. Fox read and digest the remarkable appendix on The Scope of Mechanical Explanations in Larmor's

[1] SCIENCE, October 4, 1918.

"Æther and Matter," or, an extremely simple exposition of some of the simpler of Larmor's ideas on pages 322–325 of Franklin and MacNutt's "General Physics." Others besides Bertrand Russell have recognized the Doctrinal Function.

W. S. Franklin
Barry MacNutt

SCIENTIFIC BOOKS

The Origin and Evolution of Life, on the Theory of the Action, Reaction and Interaction of Energy. By Henry Fairfield Osborn. New York, Charles Scribner's Sons. 1918. Pp. xxxi + 322. Price $3.00.

Professor Osborn's Hale Lectures, reprinted in an enlarged form in this attractive volume, raise anew the question: are the factors of organic evolution *centripetal,* consisting in the direct "moulding" action of environmental agencies upon the organism? or are they *centrifugal,* the expression of the innate formative and other physiological activities of the germ itself, operating under conditions largely independent of the immediate environment? He perceives, however, that the question can not rightly be put as one of alternatives, but that factors of both kinds necessarily enter. Organism and environment are in continual interaction; what affects the one inevitably affects the other; there is always an interchange of material and energies, constituting a more or less stable equilibrium in a well adapted organism. Organic evolution has had a complex and diversified outcome because the conditions are complex; adaptation, both of structure and activity, has developed as a distinctive feature of living beings because it is an essential condition of the vital equilibrium, *i. e.,* of survival. The factors of evolution are thus various and are classified by the author under four chief heads: (1) action of the inorganic environment, (2) of the organism itself, (3) of the germinal substance of the organism ("heredity chromatin"), and (4) of the living environment, *i. e.,* influence exerted by other living organisms, *e. g.,* competitors. Each of these "four complexes of energy" is to be conceived as itself evolving, partly independently, partly in relation with the others; and the evolution of living organisms has taken place under this fourfold or "tetrakinetic" influence. While the environment, inorganic and organic, *controls* the evolutionary process —permitting the survival only of those organisms which are adapted—the process itself is largely conditioned from *within, i. e.,* by the internal or constitutional peculiarities of the germinal substance, which throughout the book is identified with the chromatin of the germ-cells. Evolution is creative, *i. e.,* novelty perpetually arises, although at varying rates and in varying degree in the different lines of evolutionary descent; but the precise causes and conditions of its appearance remain to be determined; to explain the origin of new varieties a more complete knowledge of the physiology of the germinal substance is required. Paleontological research indicates that variations in the germ can be referred only partly, if at all, to the direct action of the environment upon the entire organism; thus rapid evolution may take place during periods in which there is little geological evidence of extensive natural change, and conversely many forms of life remain stable through the changes and chances of whole geological epochs (p. 137). Paleontology finds one evolutionary line, *e. g.,* reptiles, exhibiting active diversification at a certain period of its history, while at a later periods it relapses into conservatism at the very time when another line, the mammals, develops extraordinary creative activity (p. 231). Evolution, as observed in the paleontological succession of animal forms, often appears to progress in definite directions toward adaptive ends (pp. 146–240),—a fact which would seem to indicate a guidance by natural selection; but selection, while an important condition, can not be regarded as in itself an active agent. Repeated instances occur of characters, at first apparently non-adaptive, continuing to evolve until they become important assets in the struggle for existence. The author inclines to regard the essential agency in evolution as an apparently spontaneous germinal variability. directed along certain definite lines; this "internal